Super Neutrino Beam from FNAL to the Homestake Neutrino Detector

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INTRODUCTION The new science of neutrino mass and mixing points to the same mass scale as the Grand Unification mass scale from the unification of the fundamental constants (~10¹⁶ GeV). Further exploration needs a detector of unprecedented size and an intense neutrino beam over a very long distance. Such a project could be a landmark scientific endeavor capable of a broad attack on neutrino oscillations, nucleon decay, and neutrino astrophysics.

OBJECTIVE

- ◆Initial Detector ~300kTon
- →Plan for 1 Megaton
- ♦ Wide band neutrino beam (0.5-6 GeV)
- ♦1-2 MW of proton power
- ◆Baseline of ~1300 km

DETECTOR SITE HOMESTAKE

- ◆The chosen site for a US National Science Foundation Deep Underground Science and Engineering Laboratory
- ◆Deepest and largest such site in the western hemisphere
- ◆Capable of addressing all underground physics goals identified in recent reports.
- ◆Documented and reviewed to be capable of hosting very large underground detectors
- ◆Dedicated to scientific use, no interference from mining or transportation

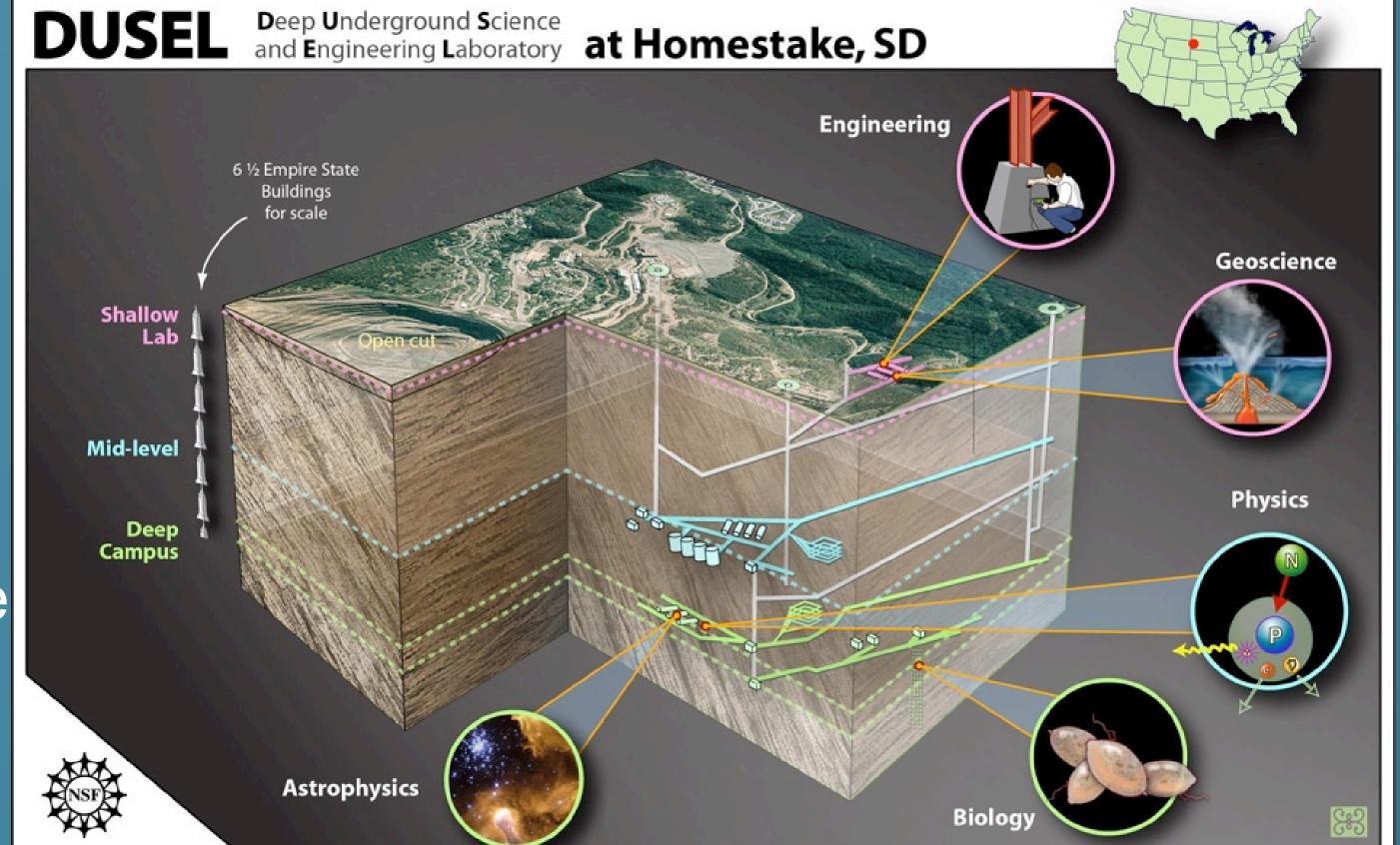
300 kTon fiducial FNAL-MI 60-120 GeV 0.5-2.0 MW The U.S. DUSEL site enjoys a natural geographical advantage (depth, long baselines) compared to other potential world sites

| Neutrino Physics | $3 \sigma \text{ reach}$ |
|---|---|
| $	heta_{13}$ Mass Hierarchy CP violation $	heta_{23}$ | $\sin^2 2\theta_{13} > 0.005$ $\sin^2 2\theta_{13} > 0.008$ $\sin^2 2\theta_{13} > 0.01$ Precision of <1% |
| Nucleon decay | 90% C.L. lifetime |



| Neutrino Astrophysics | Events |
|--------------------------------------|---------------------|
| Galactic Supernova $E_{\nu} > 5 MeV$ | 100000/10 s |
| Relic Supernova $E_{\nu} > 19 MeV$ | 50/yr |
| Solar Neutrinos $E_{\nu} > 5 MeV$ | 120000/yr |
| Atmospheric Neutrinos | $15000/\mathrm{yr}$ |
| | |

For long baseline the sensitivity is given as the value of $\sin^2 2\theta_{13}$ at which 50% of δ_{cp} values will have $\geq 3\sigma$ reach for the choice of mass hierarchy with worst sensitivity. For details on beam intensity and backgrounds see the US long baseline neutrino experiment study (arXiv:0705.4396). For nucleon decay limits we have assumed total exposure of 5 MTon-years. Solar and atmospheric neutrino rates include the effects of oscillations.



NuMI-HOMESTAKE

- ♦60-120 GeV protons Main Injector
- ◆Conventional horn focussing
- ♦1-2 MW operation
- ◆Decay tunnel 4 m dia, 400 m long

| Beam (2MW) | CC µ Events* |
|------------------|--------------------|
| 120 GeV (0 deg.) | 202000/yr |
| 60 GeV (0 deg.) | 154000/yr |
| | * w/o oscillations |



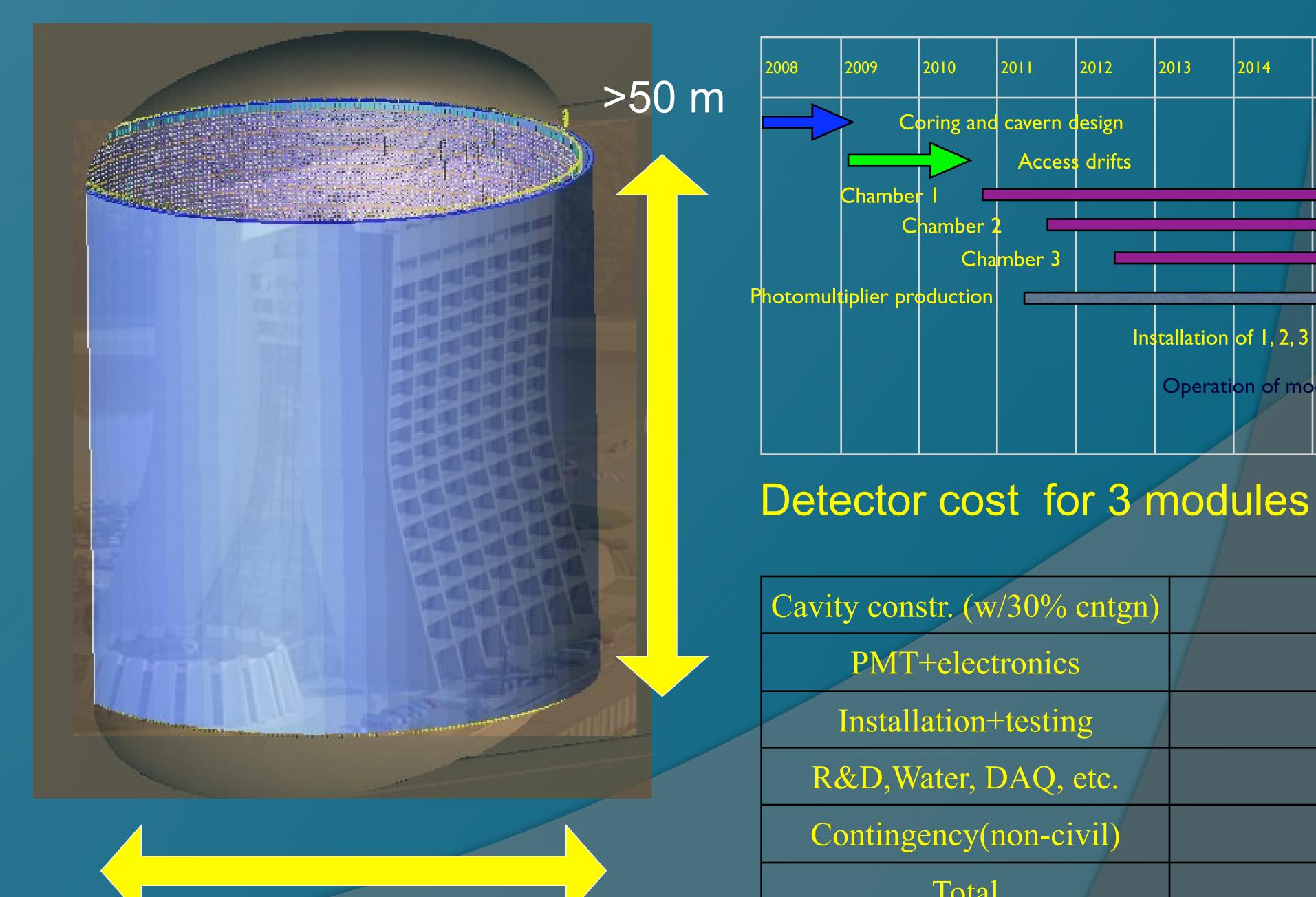
HOMESTAKE NEUTRINO DETECTOR PROJECT

DEIECIOR COSI & SCHEDULE

Coring and cavern design

Access drifts

- ◆Initial detector 300 kT in 3 modules
- ♦ Modular fiducial mass ~ 100 kilotons
- ◆Modular Shape Cylinder 50-60 m dia/height
- ◆Depth 4200 mwe (cosmic muons ~ 0.1 Hz)
- ◆PMT coverage 25% (equi. 35% with 20 in.)
- → High granularity 10-12 inch PMT 50000/mod
- ◆Construction time ~5 yrs for first, 8 yrs for all
- ◆Cost ~\$115M/module
- ◆Ultimate detector 10 modules (1 Megaton)



>50 m

Cavity constr. (w/30% cntgn) PMT+electronics \$171M Installation+testing \$36M R&D, Water, DAQ, etc. \$8M Contingency(non-civil) \$51M \$346M Total

Reference: hep-ex/0608023, http://nwg.phy.bnl.gov/fnal-bnl

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